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AN INVESTIGATION ON THE BEHAVIOR OF PALEOLANDSLIDES IN RECENT MOST REPRESENTATIVE IRANIAN STRONG EARTHQUAKES

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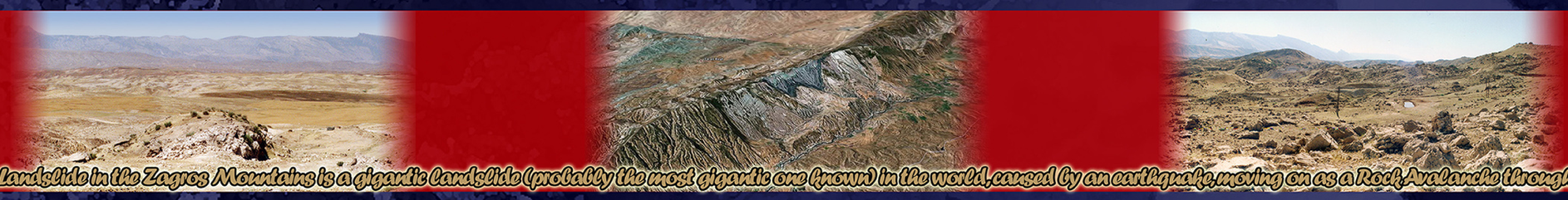


...The Seimareh Landslide in the Zagros Mountains is a gigantic landslide (probably the most gigantic one known) in the world, caused by an earthquake, moving on as a Rock Avalanche through three valleys...

Background:

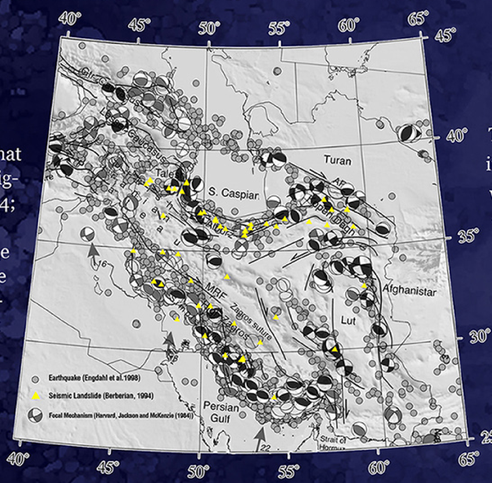
All mountainous regions record the memory of earthquakes by landslide occurrence

Over the last 25 years our investigation on 250 landslides in Iran, on the way of lifelines area, shows that most of them caused by reactivation of paleolandslides. On the other hand, most large landslides are triggered by large earthquakes (Keefer, 1984a&b; Voight & Pariseau,1978, Sidle et al.1985 in Berberian1994; Pedram,1990).

Paleolandslides which can cause significant change in morphology and environment are imprints in the history of the dynamic earth. They are more complicated that it thought and it has neglected in relevant earthquake hazard analysis methods.

We want to investigate the answer of this question that "what is the paleolandslide behavior in future earthquake events?"


Siah-Bishe, Alborz Mountains, Northern Iran



Introduction:

The Manjil earthquake of 20 June 1990 in NW Iran (Mw 7.3), the Firoozabad earthquake of 28 May 2004 in N Iran (Mw 6.2) and the Dahuiyeh (Zarand) earthquake of 22 February 2005 in central Iran (Mw 6.4), were three recent strong earthquakes in mountainous region of Iranian plateau, all of which associated with landslides, caused by earthquake shaking.

Our reassessments of landslides inventory triggered by these earthquakes in comparison with the pre-existing paleolandslides in the study area, just prior to the earthquakes events, makes it difficult to maintain this previous thought of whom suggesting that paleolandslides are reactive during the new seismic event.


Sirab Paleolandslide, Alborz Mountains, Northern Iran


Valashi Paleolandslide, Alborz Mountains, Northern Iran

Method:

We investigated and mapped the distribution of paleolandslides within the earthquake-affected areas through the combined use of field observation and aerial/space-base surveying techniques. As a result, we may resolve precise details of their shape, position and movement variation through the time of earth-

The Manjil earthquake:

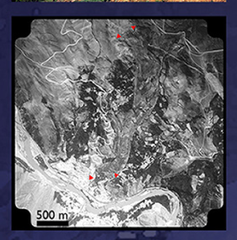
On 20 June 1990 a major earthquake (Ms 7.7) occurred in northern Iran; forty thousands of people lost their lives, and many more lost their homes. The damage was substantial and spread over a widely populated area.

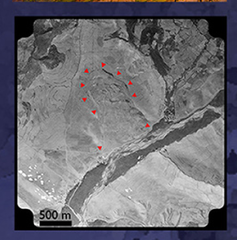
The highkinetic energy of the main shock provided such conditions that many landslides are reported. The 80 kilometer en-echelon earthquake surface rupture observed in the vicinity of Manjil, Ab-Bar, Baklor, Kabateh, Borebon and Pakdeh.


Fatalak Seismic Landslide, 190 People trapped


Khalil-Abad Seismic Landslide


Gav-Khosb Paleolandslide



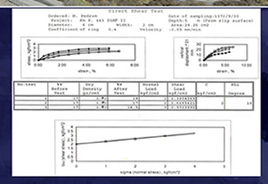


The Firoozabad earthquake:

In 2004 May 28, a strong earthquake Mw = 6.2 in Firuzabad-e-Kojur in Central Alborz caused 22 deaths (mainly due to seismic-induced landslides), and 250 injuries.

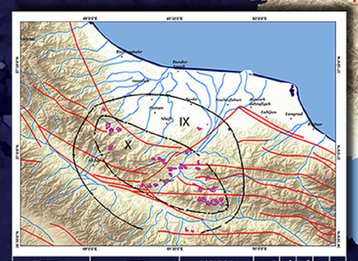
Out of 114 seismic landslides identified during field visit in mountainous roads of Nur valley, Chalus (Kandowan) and Qazvin-Alamut, more than 65% were located on the macroseismic epicenter of earthquakes. Seismic motion (and probably seismic fault rupture) is the main factor that triggered these landslides. The slope gradient is the second important factor, but we found no significant evidence of lithological control on landslide occurrences in the intensity zone VIII (EMS98). Fractures (and probably hidden faults) are still the main factors that lead to uncertainty of slope stability analysis in the area that caused large human losses. Within intensity zone VII (EMS98), most of seismic-induced landslides correlate with paleolandslides, but there is a significant decrease in their number than the macroseismic epicenter. Landslides in intensity zones V and VI are scarce, occurred on steep slopes and where the instability is easily identifiable through field visit.


Haft-Barmdaran Seismic Rock Slide

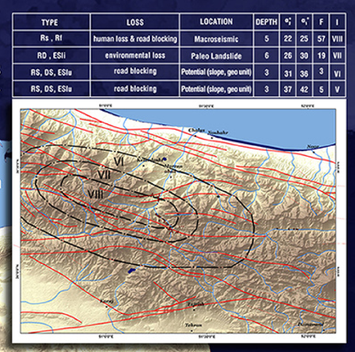


Results:

- The inventory of mega landslides in Iran shows much more of them triggered by strong earthquakes shaking.
- Sampling method of geotechnical parameters for paleolandslides, mostly done out of rupture surface, so it can't be considered reliable in stability analysis.

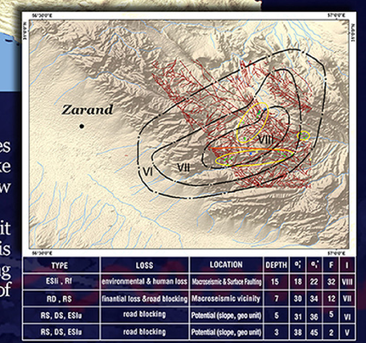


TYPE	LOSS	LOCATION	DEPTH	ϕ_s°	ϕ_r°	F	I
ESII , ESIIu	environmental & human loss	Macroseismic & Surface Faulting	35	28	34	62	X
RD , RS	finantial loss &road blocking	Macroseismic vicinity	15	45	50	15	IX



TYPE	LOSS	LOCATION	DEPTH	ϕ_s°	ϕ_r°	F	I
Rs , Rf	human loss & road blocking	Macroseismic	5	22	25	57	VIII
RD , ESII	environmental loss	Paleo Landslide	6	26	30	19	VII
RS, DS, ESIIu	road blocking	Potential (slope, geo unit)	3	31	36	3	VI
RS, DS, ESIIu	road blocking	Potential (slope, geo unit)	3	37	42	5	V

Dahuiyeh



TYPE	LOSS	LOCATION	DEPTH	ϕ_s°	ϕ_r°	F	I
ESII , Rf	environmental & human loss	Macroseismic & Surface Faulting	15	18	22	32	VIII
RD , RS	finantial loss &road blocking	Macroseismic vicinity	7	30	34	12	VII
RS, DS, ESIIu	road blocking	Potential (slope, geo unit)	5	31	36	5	VI
RS, DS, ESIIu	road blocking	Potential (slope, geo unit)	3	38	45	2	V

- Our study has suggested that none of paleolandslides has been reactivated during these studied new earthquake events and all triggered landslides have occurred in new places.
- Also we believe some of landslides occurred where it was unexpected on previous susceptible maps. May be it is based on this reason that in the most of the cases, sampling for gaining geotechnical parameter just been done out of the rupture surface of landslides.

The Dahuiyeh (Zarand) earthquake:

The 2005 February 22 earthquake (Ms=6.5, Mw=6.4) shook eastern parts of Zarand county, Central Iran. Recorded maximum ground acceleration of earthquake was 0.323g in the nearest station to epicenter. Dahuiyeh and Hatkan villages, in the macroseismic epicenter were completely destroyed and more than 60 villages sustained significant damage. The maximum estimated intensity was VIII (EMS98). The earthquake left 612 death and 1400 injuries. Seismic-induced rockfalls occurred in the region and blocked the Islamabad-Darbidkhun road, hampering the emergency response which results in more human losses. More than 85% of induced landslides were rockfall that dominantly occurred in northern mountains of Zarand County. Geological rock units such as sandstone and limestone of Bidu and Hojedk formations, in addition to Shotori dolomite and Kerman red conglomerate, all have formed cliffs which are appropriate locus for rockfalls.

Correlation among landslides induced by this earthquake and iso-intensity lines, aftershocks (especially ML>5) occurred by two months after the main shock and also structural features shows that these landslides fall within three groups.

The first group were triggered by an aftershock (ML=5.1) in 2005 April 30 near the Biduiyeh village. The second group is located around the Sardowan village. This group has greatest density and is lithologically controlled. The third group located along the Islamabad-Darbidkhun-Qanat Shibdeh road has a similar trend with earthquake surface rupture.


Dahuiyeh Seismic landslide


Seismic Rock Fall in Access Road to Dahuiyeh

References:

- Berberian, M., (1994), Natural hazards and the first earthquake catalogue of Iran, Vol.1, Historical hazard in Iran prior to 1900, International institute of earthquake engineering and seismology (IIEES), 603p.
- Jibson R.W., E.L. Harp and J.A. Michael (2000), a method for producing digital probabilistic seismic landslide hazard maps, Engineering Geology an International Journal, Vol. 58, No53-4, December, pp.271-289.
- Pedram H., Earthquakes, Tectonics Activities and Landslide, proceedings of the first international conference on Seismology and Earthquake Engineering, Vol. I, May 27-29, 1991, International Institute of earthquake engineering and seismology (IIEES) Tehran, Iran.
- Nasiri SH., 2004, Seismic Landslide Hazard Zonation For The Northern Tehran Capital, M. Sc. Thesis, Tarbiat Modares University, Tehran, Iran.